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Original Article

Tidal Energy: Advantage and disadvantage

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Abstract

Marine current energy is one of the most exciting emerging forms of renewable energy. Tidal energy is produced through the use of tidal energy generators. Large underwater turbines are placed in areas with high tidal movements, and are designed to capture the kinetic motion of the ebbing and surging of ocean tides in order to produce electricity. Tidal power has great potential for future power and electricity generation because of the massive size of the oceans. Tidal energy is a form of hydropower that converts the energy of the tides into electricity or other useful forms of power. The tide is created by the gravitational effect of the sun and the moon on the earth causing cyclical movement of the seas. Tidal energy is therefore an entirely predictable form of renewable energy.

1. Introduction

Marine currents, unlike many other forms of renewable energy, are a consistent source of kinetic energy caused by regular tidal cycles influenced by the phases of the moon. Intermittency is a problem for wind, wave and solar power as the sun doesn't always shine and the wind doesn't always blow. These sources of renewable energy often require backup from traditional forms of power generation. However, the inherent predictability of tidal power is highly attractive for grid management, removing the need for back-up plants powered by fossil fuels. Tidal turbines are installed on the seabed at locations with high tidal current velocities, or strong continuous ocean currents where they extract energy from the flowing water. Tidal turbines are very much like underwater windmills except the rotors are driven by consistent, fast-moving currents. The submerged rotors harness the power of the marine currents to drive generators, which in turn produce electricity. Water is 832 times denser than air and consequently tidal turbine rotors can be much smaller than wind turbine rotors thus they can be deployed much closer together and still generate equivalent amounts of electricity. Devices that harness marine current energy present a unique set of engineering challenges in terms of design, installation and maintenance.[1]

1.1 Tidal Energy can be harnessed in two forms:

1.1.1 Tidal Range

Tidal Range is the vertical difference in height between the high tide and the succeeding low tide. Artificial tidal barrages or lagoons may be constructed to capture the tide. Turbines in the barrier or lagoon generate electricity as the tide floods into the reservoir; water thus retained can then be released through turbines, again generating electricity once the tide outside the barrier has receded.[2]

1.1.2 Tidal Stream

Tidal Stream is the flow of water as the tide ebbs and floods, and manifests itself as tidal current. Tidal Stream devices seek to extract energy from this kinetic movement of water, much as wind turbines extract energy from the movement of air. The sea currents created by movement of the tides are often magnified where water is forced to flow through narrow channels or around headlands. There are a number of locations around the coastline of the UK where the tidal stream resource is high, and it is in these areas where early technology developments are taking place to explore the prospect of harnessing tidal energy.[3][4]

1.2 Advantages of Tidal Energy

1) It is an inexhaustible source of energy.
2) Tidal energy is environment friendly energy and doesn't produce greenhouse gases.
3) As 71% of Earth's surface is covered by water, there is scope to generate this energy on large scale.
4) We can predict the rise and fall of tides as they follow cyclic fashion.
5) Efficiency of tidal power is far greater as compared to coal, solar or wind energy. Its efficiency is around 80%.
6) Although cost of construction of tidal power is high but maintenance costs are relatively low.
7) Tidal Energy doesn't require any kind of fuel to run.
8) The life of tidal energy power plant is very long.
9) The energy density of tidal energy is relatively higher than other renewable energy sources.
10) Renewable: Tidal Energy is a renewable energy source. This energy source is a result of the gravitational fields from both the sun and the moon, combined with the earth's rotation around its axis, resulting in high and low tides.[5]
11) Green: Tidal power is an environmentally friendly energy source. In addition to being a renewable energy, it does not emit any climate gases and does not take up a lot of space [6].
12) Predictable: Tidal currents are highly predictable. High and low tide develop with well-known cycles, making it easier to construct the system with right dimensions, since we already know what kind of powers the equipment will be exposed to.[7]
13) Effective at Low Speeds: Water has 1000 times higher density than air, which makes it possible to generate electricity at low speeds. Calculations show that power can be generated even at 1m/s.[8]

14) Long Lifespans: We have no reason to believe that tidal power plants are not long lived. This ultimately reduces the cost these power plants can sell their electricity, making tidal energy more cost-competitive.[9]

1.3 Disadvantages of Tidal Energy

1) Cost of construction of tidal power plant is high.
2) There are very few ideal locations for construction of plant and they too are localized to coastal regions only.
3) Intensity of sea waves is unpredictable and there can be damage to power generation units.
4) Influences aquatic life adversely and can disrupt migration of fish.
5) The actual generation is for a short period of time. The tides only happen twice a day so electricity can be produced only for that time.
6) Frozen sea, low or weak tides, straight shorelines, low tidal rise or fall are some of the obstructions.
7) This technology is still not cost effective and more technological advancements are required to make it commercially viable.
8) Usually the places where tidal energy is produced are far away from the places where it is consumed. This transmission is expensive and difficult.
9) Environmental Effects: As previously mentioned, the effects tidal power plants have on the environment are not completely determined yet. We know that these power plants generate green electricity [10]
10) Close to Land: Tidal power plants needs to be constructed close to land. This is also an area where technological solutions are being worked on. Hopefully in a few years we can exploit weaker tidal currents, at locations further out in the sea.[11]
11) Expensive: It is important to realize that the methods for generating electricity from tidal energy is a relatively are relatively new technologies. It is projected that tidal power will be commercially profitable within 2020 with better technology and larger scales.[12]

2. The world's five biggest tidal power plants

2.1 Sihwa Lake Tidal Power Station, South Korea - 254MW

With an output capacity of 254MW, the Sihwa Lake tidal power station located on Lake Sihwa, approximately 4km from the city of Siheung in Gyeonggi Province of South Korea, is the world's biggest tidal power plant. The project, owned by Korea Water Resources Corporation, was opened in August 2011 and utilises a 12.5km long seawall constructed in 1994 for flood mitigation and agricultural purposes. Power is generated on tidal inflows into the 30km2 basin with the help of ten 25.4MW submerged bulb turbines. Eight culvert type sluice gates are used for the water outflow from the barrage. The $355.1m tidal power project was built between 2003 and 2010. Daewoo Engineering & Construction was the engineering, procurement and construction (EPC) contractor for the project. The annual generation capacity of the facility is 552.7GWh.[13]

Fig 1: Sihwa Lake Tidal Power Station, South Korea
(http://www.power-technology.com/)

2.2 La Rance Tidal Power Plant, France - 240MW

The 240MW La Rance tidal power plant on the estuary of the Rance River in Brittany, France, has been operational since 1966 making it the worlds oldest and second biggest tidal power station. The renewable power plant, currently operated by Électricité de France (EDF), has an annual generation capacity of 540GWh. The La Rance tidal power facility, built between 1961 and 1966, involved the construction of a 145.1m long barrage with six fixed wheel gates and a 163.6m-long dyke. The basin area covered by the plant is 22km2. Power is produced through 24 reversible bulb turbines with a rated capacity of 10MW each.The plant site features an average tidal range of 8.2m, the highest in France. Electricity is fed into the 225kV national transmission network serving the needs of approximately 130,000 households every year.[14]

Fig 2: La Rance Tidal Power Plant, France
(http://www.power-technology.com/)

2.3 Swansea Bay Tidal Lagoon, United Kingdom - 240MW

The 240MW Swansea Bay Tidal Lagoon project, to be built at Swansea Bay in the UK, is the world's biggest tidal power project and will become the world's third biggest tidal power project upon completion. The planning application for the £850m ($1.4bn) project was approved in March 2013. The plant will be located at a site with average tidal range of 8.5m and will involve the construction of a 9.5km-long sea wall or breakwater facility to create a lagoon cordoning off 11.5km2 of sea. The plant will use reversible bulb turbines to generate power as water passes in and out of the lagoon with the rise and fall of tides. The ground breaking for the tidal power project is scheduled for 2015 while full commissioning is expected in 2018. The tidal lagoon, with an estimated annual power generation capacity 400GWh, will power over 120,000 homes for 120 years.[15]

Fig 3: Swansea Bay Tidal Lagoon, United Kingdom
(http://www.power-technology.com/)

2.4 MeyGen Tidal Energy Project, Scotland - 86MW

MeyGen Tidal Energy Project located in the Inner Sound of the Pentland Firth off the north coast of Caithness, Scotland, is currently the world's biggest underwater tidal turbine power project under development. The tidal array project received offshore planning consent

for its 86MW first phase development from the Scottish Government towards the end of 2013. The second phase development of the project is expected to raise the total installed capacity to 398MW by 2020. The MyGen project was initiated in 2006 by the Scottish company MeyGen, a joint venture between the tidal technology company Atlantis Resources and Morgan Stanley. Atlantis Resources acquired full ownership of the tidal array project in December 2013. Construction is expected to start for a demonstration array involving up to six AR1000 single-rotor tidal turbines in 2014 with final commissioning expected in 2015. The first 1MW prototype of the 22.5m tall AR1000 tidal turbine with 18m rotor diameter was deployed at the European Marine Energy Centre in 2011.[16]

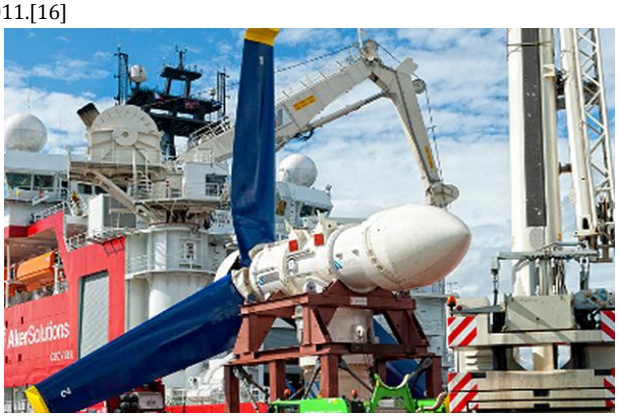

Fig 4: MeyGen Tidal Energy Project, Scotland
(http://www.power-technology.com/)

2.5 Annapolis Royal Generating Station, Canada - 20MW

The Annapolis tidal power generating station located in the Annapolis Basin, a sub-basin of the Bay of Fundy in Canada, has an installed capacity of 20MW making it the world's third biggest operating tidal power plant. It generates 50GWh of electricity annually to power over 4,000 homes. The plant, operated by Nova Scotia Power, came online in 1984 after four years of construction. The plant utilises a causeway built in the early 1960s, which was originally designed to serve as a transportation link as well as a water control structure to prevent flooding. The power plant comprises of a single four blade turbine and sluice gates. The gates are closed as the incoming tides create a head pond in the lower reaches of the Annapolis River upstream of the causeway. The gates are opened and the water rushing into the sea drives the turbine to generate power when a head of 1.6m or more is created between the head pond and sea side with the falling of the tide.[17]

Fig 5: Annapolis Royal Generating Station, Canada
(http://www.power-technology.com/)

3. Result and discussion

Energy consultants have the duty to study the tide patterns that are occurring at any location and this can help them to devise an appropriate technology to harness the same tidal energy. Tidal fences are a perfect example of augmented technology used to apply the tides for energy production. Green energy sources such as the tides have many advantages in comparison with the competing technologies such as solar and wind energy. Currently, we cannot apply solar energy during the nighttime. We have to rely upon battery packs in order to store the solar energy for nighttime usage. Various limitations exist in wind energy too. Environmental activists have come out with the fact that wind turbines can disrupt with the migration procedures of birds. Power sources that are still relying on the application of fossil fuels will only help in augmenting the levels of greenhouse gases within the atmosphere. The niche of tidal energy production has its share of disadvantages too. For instance, some studies indicate that we are only able to harness a fraction of the kinetic energy produced by the waves. It is only a matter of time before we have access to advanced technologies, which will enable us to unleash the full potential of tidal energy.

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